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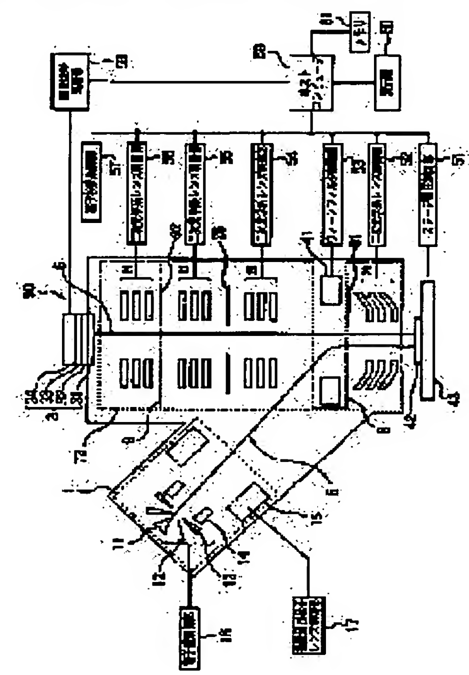
(54) BOARD INSPECTION APPARATUS AND BOARD INSPECTION SYSTEM PROVIDED WITH THE SAME AS WELL AS CONTROL METHOD FOR BOARD INSPECTION APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a board inspection apparatus by which the magnification chromatic aberration of a secondary electron beam can be suppressed, while the irradiation region of a primary electron beam is being ensured, to provide an inspection system provided with the board inspection apparatus, and to provide a control method for the board inspection apparatus.



SOLUTION: In a board inspection apparatus 90 which uses a nearly rectangular electron beam, an image-forming optical system as a telecentric system which is conjugate with an image-formation optical system in which a third lens 23 and a fourthlens 24 are controlled by secondary-optical system lens control parts 55, 56 and which is formed of a cathode lens 21 and a second lens 22 is formed, and square aperture diaphragms are arranged at focal planes 8, 9 which are mutually conjugate. As the square aperture diaphragms, movable rectangular diaphragms which are connected respectively to a driving mechanism using a piezoelectric element, comprising two rectangular flat boards arranged and installed in parallel in the direction of the long direction and in which their diaphragm widths formed of edges of sides facing to the rectangular flat boards can be adjusted are used. The movable rectangular diaphragms are arranged and installed in such a way that their long axis becomes a direction identical to that of the long axis of the cross-sectional shape of a primary electron beam 5 and that the long axis is at right angles to the long axis of the movable rectangular diaphragms.

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CLAIMS

[Claim(s)]

[Claim 1] A primary-electron beam exposure means to irradiate as a primary-electron beam, and said primary-electron beam an electron beam to the substrate which is a sample The secondary electron beam containing the secondary electron and reflection electron which whenever [angle-of-incidence] was changed, were made it to carry out

incidence at right angles to the front face of said substrate, and were generated from said substrate in response to the exposure of said primary-electron beam While controlling and carrying out image formation of said secondary electron beam including the electron beam deflection means passed with an incorporation include angle, and said electron beam deflection means Two or more map projection means to control said secondary electron beam to make telecentric system [****] to mutual [which forms the field where the image formation optical system advances in parallel with a beam shaft before and behind a focus], An electron beam detection means to detect said secondary electron beam by which image formation was carried out with said map projection means of the last stage, and to output as a picture signal, An aperture angle diaphragm of the first which is arranged in the focal plane which is a flat surface perpendicular to the beam shaft of said secondary electron beam through said focus within said map projection means after the second step, and determines said secondary electron beam spread angle, Substrate test equipment equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of said substrate in response to supply of said picture signal from said electron beam detection means.

[Claim 2] said aperture angle diaphragm of the first -- each -- telescopic motion -- the substrate test equipment according to claim 1 with which it has free diaphragm width of face, and the direction of a major axis is mutually characterized by having the first [which fluctuates the movable rectangle diaphragm of the first and the second which carries out an abbreviation rectangular cross, and the these firsts and second drawing width of face of a movable rectangle diaphragm, respectively], and second rectangle diaphragm driving means.

[Claim 3] It has further an aperture angle diaphragm of the second arranged in the focal plane of said telecentric system in the field between said electron beam deflection means and said substrates. Said aperture angle diaphragm of the first It has said movable rectangle diaphragm of the first and said first rectangle diaphragm driving means. Said aperture angle diaphragm of the second It is substrate test equipment according to claim 1 or 2 which is equipped with said movable rectangle diaphragm of the second and said second rectangle diaphragm driving means, and is characterized by arranging a movable rectangle diaphragm of said first and the second so that the direction of a major axis may carry out an abbreviation rectangular cross mutually.

[Claim 4] A movable rectangle diaphragm of said first and the second is substrate test equipment according to claim 2 or 3 characterized by forming said aperture angle diaphragm by having the metal plate of two sheets, respectively, and the metal plate of

these two sheets opposing and arranging it in a long side.

[Claim 5] Said rectangle diaphragm driving means is substrate test equipment according to claim 4 characterized by having the piezoelectric device connected with said metal plate, driving said metal plate based on change of the configuration of this piezoelectric device, and adjusting the distance between [of said two sheets] metal monotonous.

[Claim 6] A cross-section configuration perpendicular to the direction of radiation of said primary-electron beam is substrate test equipment according to claim 1 to 5 characterized by making an abbreviation rectangle.

[Claim 7] Substrate check system equipped with CPU, substrate test equipment according to claim 1 to 6, a signal-processing means to process said picture signal and to output image data, and a storage means to store said image data.

[Claim 8] A primary-electron beam exposure means to irradiate the electron beam which has the cross-section configuration of an abbreviation rectangle in the substrate which is a sample as a primary-electron beam, the secondary electron and reflection electron which were generated from said substrate in response to the exposure of said primary-electron beam -- said sample -- abbreviation -- with the first symmetry-of-revolution electrostatic lens which draws in the perpendicular direction and carries out outgoing radiation as a secondary electron beam Change whenever [to said sample of said primary-electron beam / angle-of-incidence], and incidence of said primary-electron beam is carried out at right angles to said sample front face. The electric-field field superposition mold spectroscope which passes said secondary electron beam by which outgoing radiation was carried out from said first symmetry-of-revolution electrostatic lens with an incorporation include angle, The second symmetry-of-revolution electrostatic lens which forms the first image formation optical system which is arranged in the latter part of said electric-field field superposition mold spectroscope, and makes telecentric system with said first symmetry-of-revolution electrostatic lens, it arranges in the first focal plane which is a focal plane of said first image formation optical system -- having -- the direction of incidence of said primary-electron beam -- a major axis -- carrying out -- telescopic motion -- with an aperture angle diaphragm of the first which has the metal plate of two sheets isolated in parallel with mutual by free diaphragm width of face The first aperture angle diaphragm drive which it has [first] the first piezoelectric device and fluctuates the drawing width of face of said aperture angle diaphragm of the first, It is arranged in the latter part of the field diaphragm arranged in the image formation side of said first image formation optical system, and said field diaphragm. Form the

second image formation optical system which makes said first image formation optical system and telecentric system [****], and even if few, the third of a pair, and the fourth symmetry-of-revolution electrostatic lens, Are the focal plane of said second image formation optical system, and it is arranged in said first focal plane and the second focal plane [****]. the direction of a major axis of said aperture angle diaphragm of the first, and the direction which carries out an abbreviation rectangular cross -- a major axis -- carrying out -- telescopic motion -- with an aperture angle diaphragm of the second which has the metal plate of two sheets isolated in parallel with mutual by free diaphragm width of face The second aperture angle diaphragm drive which it has [second] the second piezoelectric device and fluctuates the drawing width of face of said aperture angle diaphragm of the second, An electron beam detection means to detect said secondary electron beam by which image formation was carried out with said fourth symmetry-of-revolution lens, and to output as a picture signal, Substrate check system equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of said substrate in response to supply of said picture signal from said detection means, and the host computer which performs processing of said picture signal.

[Claim 9] An electron beam exposure means to irradiate an electron beam as a primary-electron beam at the substrate which is a sample, Said primary-electron beam changes whenever [incident angle], and it carries out incidence at right angles to the front face of said substrate. The electron beam deflection means which passes the secondary electron beam containing the secondary electron and reflection electron which were generated from said substrate in response to the exposure of said primary-electron beam with an incorporation include angle, Two or more map projection means to which image formation of said secondary electron beam is carried out including said electron beam deflection means, An electron beam detection means to detect said secondary electron beam by which image formation was carried out with said map projection means of the last stage, and to output as a picture signal, It is the control approach of substrate test equipment equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of said substrate in response to supply of said picture signal from said electron beam detection means. Image formation of said secondary electron beam is controlled and carried out so that telecentric system [**** / said secondary electron beam / mutual] may be made with said two or more map projection means. The control approach of substrate test equipment of reducing the chromatic aberration of magnification of said secondary electron beam while securing the exposure field to said

substrate of said primary-electron beam by arranging an aperture angle diaphragm of the first in the first focal plane within said map projection means after the second step.
[Claim 10] said aperture angle diaphragm of the first -- each -- telescopic motion -- the control approach of the substrate test equipment according to claim 9 which opens independently mutually to two directions which carry out an abbreviation rectangular cross, and controls an angle by having free diaphragm width of face, and each major axis's forming mutually by two movable rectangle diaphragms which carry out an abbreviation rectangular cross, and fluctuating the drawing width of face of said movable rectangle diaphragm using the rectangle diaphragm driving means which it has further, respectively.
[Claim 11] Are the focal plane of said map [the first step of] projection means, and an aperture angle diaphragm of the second is further arranged in the second focal plane in the field between said electron beam deflection means and said substrates. It forms, respectively by movable rectangle diaphragm of the first which has free diaphragm width of face, and the second. an aperture angle diaphragm of said first and the second -- telescopic motion -- a movable rectangle diaphragm of said first and the second The control approach of the substrate test equipment according to claim 9 which arranges so that each major axis may carry out an abbreviation rectangular cross mutually, is equipped with the driving means which fluctuates each said first and second diaphragm width of face of a movable rectangle diaphragm, opens independently to two directions which carry out an abbreviation rectangular cross, respectively mutually, and controls an angle.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the control approach of substrate test equipment at the substrate check system list using the substrate test equipment and this which reduce the chromatic aberration of magnification, securing the exposure field to the sample of a primary-electron beam especially to the substrate check system list using the substrate test equipment and this which used the electron beam about the substrate inspection approach.

[0002]

[Description of the Prior Art] The sensibility required of the defect on substrate front faces, such as a semiconductor wafer and a photo mask, and detection of a foreign matter becomes still higher with high integration of a semiconductor device, optical is replaced from the limitation of the pattern defect inspection by optical in recent years, and the semi-conductor pattern defect test equipment using an electron beam is developed. This test equipment forms an electron beam with an electron irradiation means, and irradiates the substrate which is a sample as a primary-electron beam. The secondary electron generated according to change of the configuration on the front face of a sample, the quality of the material, and potential, With a map projection means, lead a reflection electron and a back scattering electron, converge them, and expansion projection is carried out as a secondary electron beam at an electronic detecting element. It is equipment which obtains a sample surface image, and the technique of raising a scan speed is especially proposed by JP,7-249393,A by irradiating a sample by using the electron beam of a line, a rectangle, or the cross-section configuration of prolate ellipsoid as a primary-electron beam. moreover, in addition to this technique, a primary-electron beam is deflected with the Wien filter (Wien filter) which is an electron beam deflection means, and incidence is perpendicularly carried out to a sample front face -- making -- in addition -- and the method of making the inside of the same Wien filter go straight on, and leading a secondary electron beam to a map projection means is proposed by Japanese-Patent-Application-No. No. 300275 [nine to] application. The outline of the substrate check system equipped with the test equipment shown in Japanese-Patent-Application-No. No. 300275 [nine to] application is shown in ~~drawing 8~~ .

[0003] The substrate check system 100 shown in this drawing The primary optical

system 1 and this The electron gun control section 16 to control and two or more step quadrupole lens control section 17, the secondary optical system 2, the secondary optical-system lens control sections 52, 54-56 that control this, the electronic detecting element 3, the electronic detection control section 57 which controls this, Wien filter 41, and this It has the stage armature-voltage control section 51 which controls the Wien filter control section 53, the stage 43, and this which are controlled, the picture signal processing section 58, a host computer 59, a display 60, and memory 61.

[0004] The primary optical system 1 is equipped with an electron gun and two or more steps of quadrupole lens systems. the lanthanum hexa in which an electron gun has the electron emission side of the rectangle of 100-700 micrometers of major axes, and 15 micrometers of minor axes -- a bora -- the id (it is called LaB6) -- it has cathode 11, the Wehnelt cylinder (Wehnelt cylinder) 12 which has rectangle opening, the anode plate 13 which an electron beam is pulled out and irradiated as a primary-electron beam 5, and the deflecting system 14 for beam shaft adjustment. The electron gun control section 16 controls the acceleration voltage of the primary-electron beam 5, an outgoing radiation current, etc. Moreover, the quadrupole lens system is equipped with two or more step quadrupole lens 15 which converges the primary-electron beam 5 based on control of two or more step quadrupole lens control section 17.

[0005] It converges so that it may have the cross-section configuration of an abbreviation rectangle by two or more steps of the quadrupole lenses 15 and control sections 17, and incidence of the primary-electron beam 5 emitted from cathode 11 is carried out from across to Wien filter 41. Here, since cathode 11 has the rectangular electron emission side, the cross-section configuration of an electron beam can serve as an abbreviation rectangle, and the exposure field to a sample can expand it, and it can raise a patient throughput. In addition, a patient throughput can be raised even if it uses the electron beam which has the elongated-shaped cross section where aspect ratios other than a rectangle, such as a line and prolate ellipsoid, exceed 1. However, the electron beam of not only an elongated shape but various cross-section configurations may be used.

[0006] With Wien filter 41, the primary-electron beam 5 is deflected in the perpendicular direction to the front face of a sample 42, and carries out outgoing radiation of Wien filter 41. Then, it is reduced with the cathode lens 21 which is a symmetry-of-revolution electrostatic lens, and the primary-electron beam 5 is irradiated on a sample 42 as 100 micrometers of major-axis numbers, and an abbreviation rectangle beam of about 25 micrometers of minor axes.

[0007] The fundamental configuration of Wien filter 41 is shown in ~~drawing 9~~ . As

shown in this drawing, Wien filter 41 countered mutually, respectively, has been arranged, and is equipped with two electrodes 41a and 41b of a rectangular parallelepiped controlled by the Wien filter control section 53 (refer to ~~drawing 8~~), and two magnetic poles 41c and 41d. In the three-dimensions space of XYZ shown in this drawing, if the Z-axis is used as the optical axis of a map projection system, Wien filter 41 will have the structure where electric field E and Field B were made to intersect perpendicularly, in XY flat surface perpendicular to the Z-axis, and will serve to make only the charge particle which fills Vienna condition qE=vB (q is a particle charge and v is the rate of a rectilinear-propagation charge particle) go straight on to the charge particle which carried out incidence.

[0008] ~~Drawing 10~~ (a) and (b) are the explanatory views of the electron beam orbit which passes Wien filter 41, and are the sectional view of ~~drawing 9~~ which cut all at XZ flat surface (Y= 0). As shown in ~~drawing 10~~ (a), with this substrate check system 100, to the primary-electron beam 5 which carried out incidence to Wien filter 41, the force FB by the field and the force FE by electric field act in the same direction, and the primary-electron beam 5 is deflected so that incidence may be perpendicularly carried out to the front face of a sample 42. this force FB according [as opposed to / as shown in this drawing (b) on the other hand / the secondary electron beam 6] to a field, and the force FE by electric field -- hard flow -- acting -- in addition -- and since Vienna condition FB=FE is materialized, the secondary electron beam 6 goes straight on, without deviating, and carries out incidence to secondary optical system.

[0009] ~~drawing 8~~ -- return and a stage 43 -- each beam shaft of the primary-electron beam 5 and the secondary electron beam 6 -- receiving -- level -- migration -- it has a free device, the sample 42 installed in the top face is moved by this, and all the front faces can be scanned now. Moreover, a stage 43 can impress a negative electrical potential difference now to a sample 42 by the stage armature-voltage control section 51. Thereby, the incidence damage to the sample 42 by the primary-electron beam 5 can be reduced.

[0010] The electronic detecting element 3 is equipped with the MCP (Micro Channel Plate) detector 31, the fluorescent screen 32, the light guide 33, and the image sensor 34 that has CCD etc. The secondary electron beam 6 which carried out incidence to the MCP detector 31 through the secondary optical system 2 is amplified by the MCP detector 31, and is irradiated by the fluorescent screen 32, and the fluorescence image generated there is detected by the image sensor 34 as a picture signal through a light guide 33.

[0011] This picture signal is supplied to the image-processing section 58, and various

kinds of signal processing is made and it is supplied to a host computer 59 as image data. A host computer 59 performs preservation of the image data using memory 61 etc. while carrying out image display of this image data by the display 60.

[0012] The secondary optical system 2 is equipped with the field diaphragm 26 installed between the cathode lens 21, the second lens 22, the third lens 23, the fourth lens 24, and the second lens 22 and the third lens 23 that are a symmetry-of-revolution electrostatic lens. The cathode lens 21, the second lens 22, the third lens 23, and the fourth lens 24 are controlled by the secondary optical-system lens control sections 52, 54, 55, and 56, respectively. The secondary optical system 2 passed along the focus F1 between Wien filter 41 and the cathode lens 21, and is equipped with the aperture angle diaphragm 25 arranged in the focal plane 8 which is a flat surface perpendicular to a beam shaft again. Thus, the reason for opening to the location of a focal plane 8 and arranging the angle diaphragm 25 If it is going to perform image formation only with the cathode lens 21 about the secondary electron beam 6, since a lens operation will become strong and it will be easy to generate aberration As shown in the explanatory view of the beam orbit 7 of ~~drawing 7~~ , it doubles with the second lens 22. Both telecentric system, both [namely,] an entrance pupil and an outgoing radiation pupil -- although -- it is because the chromatic aberration of magnification of the secondary electron beam 6 can be stopped by forming the optical system which exists in infinite distance, making 1 time of image formation perform, opening to the focal plane 8 of this image formation optical system 105 further, and installing the angle diaphragm 25.

[0013]

[Problem(s) to be Solved by the Invention] However, in the conventional substrate check system 100 which has such structure, in order to reduce the chromatic aberration of magnification of the secondary electron beam 5, when the diaphragm of the aperture angle diaphragm 25 was narrowed, thereby, there was a fault that the exposure field to the sample 42 top of the primary-electron beam 5 was restricted. This is because it is the Keller lighting (Koehler illumination) system of the primary-electron beam 5 from the aperture angle diaphragm 25 to a sample 42 opening, carrying out incidence to the focus F1 on the angle diaphragm 25, and the cathode lens 21 receiving a lens operation, and illuminating perpendicularly to a sample 42.

[0014] Moreover, there is a case where he wants to extend or narrow opening of the aperture angle diaphragm 25 depending on the experimental contents, and in order to optimize a diaphragm corresponding to this, it is necessary to exchange the aperture

angle diaphragm 25. However, in the Prior art, the vacuum ambient atmosphere in equipment had to be opened for whenever [of exchange / every], and it had the fault that an equipment utilization ratio got very bad.

[0015] This invention is made in view of the above-mentioned situation, and the purpose is in providing with the control approach of substrate test equipment the check system list equipped with the substrate test equipment and this which can control the chromatic aberration of magnification of a secondary electron beam on a par with a Prior art, securing the exposure field of a primary-electron beam.

[0016]

[Means for Solving the Problem] This invention aims at solution of the above-mentioned technical problem with the following means. According to this invention (claim 1), namely, a primary-electron beam exposure means to irradiate as a primary-electron beam and the above-mentioned primary-electron beam an electron beam to the substrate which is a sample The secondary electron beam containing the secondary electron and reflection electron which whenever [angle-of-incidence] was changed, were made it to carry out incidence at right angles to the front face of the above-mentioned substrate, and were generated from the above-mentioned substrate in response to the exposure of the above-mentioned primary-electron beam While controlling and carrying out image formation of the above-mentioned secondary electron beam including the electron beam deflection means passed with an incorporation include angle, and this electron beam deflection means Two or more map projection means to control the above-mentioned secondary electron beam to make telecentric system [****] to mutual [which forms the field where the image formation optical system advances in parallel with a beam shaft before and behind a focus], An electron beam detection means to detect the above-mentioned secondary electron beam by which image formation was carried out with the map projection means of the last stage, and to output as a picture signal, An aperture angle diaphragm of the first which is arranged in the focal plane which is a flat surface perpendicular to the beam shaft of the above-mentioned secondary electron beam through the focus within the above-mentioned map projection means after the second step, and determines the above-mentioned secondary electron beam spread angle, Substrate test equipment equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of the above-mentioned substrate in response to supply of the above-mentioned picture signal from the above-mentioned electron beam detection means is offered.

[0017] an aperture angle diaphragm of the above first -- each -- telescopic motion -- it

has free diaphragm width of face, and the direction of a major axis is good for mutual to have the first [which fluctuates the movable rectangle diaphragm of the first and the second which carries out an abbreviation rectangular cross, and the these firsts and second drawing width of face of a movable rectangle diaphragm, respectively], and second rectangle diaphragm driving means.

[0018] The substrate test equipment concerning this invention is further equipped with an aperture angle diaphragm of the second arranged in the focal plane of the above-mentioned telecentric system in the field between the above-mentioned electron beam deflection means and the above-mentioned substrate. An aperture angle diaphragm of the above first is equipped with the rectangle diaphragm driving means of a movable rectangle diaphragm of the above first and the above first. An aperture angle diaphragm of the above second It has the rectangle diaphragm driving means of a movable rectangle diaphragm of the above second and the above second, and, as for a movable rectangle diaphragm of the above-mentioned first and the second, it is desirable to be arranged so that the direction of a major axis may carry out an abbreviation rectangular cross mutually.

[0019] Moreover, as for a movable rectangle diaphragm of the above-mentioned first and the second, it is desirable by having the metal plate of two sheets, respectively, and the metal plate of these two sheets opposing and arranging it in a long side, to form the above-mentioned aperture angle diaphragm.

[0020] Moreover, the above-mentioned rectangle diaphragm driving means is good to have the piezoelectric device connected with the above-mentioned metal plate, to drive the above-mentioned metal plate based on change of the configuration of this piezoelectric device, and to adjust the distance between [of the two above-mentioned sheets] metal monotonous.

[0021] Moreover, a cross-section configuration perpendicular to the direction of radiation of the above-mentioned primary-electron beam is good to make an abbreviation rectangle.

[0022] Moreover, according to this invention (claim 7), the substrate check system equipped with CPU, the substrate test equipment concerning above-mentioned this invention, a signal-processing means to process the above-mentioned picture signal and to output image data, and a storage means to store this image data is offered.

[0023] Moreover, a primary-electron beam exposure means to irradiate the electron beam which has the cross-section configuration of an abbreviation rectangle in the substrate which is a sample as a primary-electron beam according to this invention (claim 8), top Norikazu -- the secondary electron and reflection electron which were

generated from the above-mentioned substrate in response to the exposure of degree electron beam -- the above-mentioned sample -- abbreviation -- with the first symmetry-of-revolution electrostatic lens which draws in the perpendicular direction and carries out outgoing radiation as a secondary electron beam Change whenever [to the above-mentioned sample of the above-mentioned primary-electron beam / angle-of-incidence], and incidence of the above-mentioned primary-electron beam is carried out at right angles to the above-mentioned sample front face. The electric-field field superposition mold spectroscope passed at an incorporation include angle with the same above-mentioned secondary electron beam by which outgoing radiation was carried out from the symmetry-of-revolution electrostatic lens of the above first, The second symmetry-of-revolution electrostatic lens which forms the first image formation optical system which is arranged in the latter part of this electric-field field superposition mold spectroscope, and makes telecentric system with the symmetry-of-revolution electrostatic lens of the above first, it arranges in the first focal plane which is a focal plane of the image formation optical system of the above first -- having -- the direction of incidence of the above-mentioned primary-electron beam -- a major axis -- carrying out -- telescopic motion -- with an aperture angle diaphragm of the first which has the metal plate of two sheets isolated in parallel with mutual by free diaphragm width of face The first aperture angle diaphragm drive which it has [first] the first piezoelectric device and fluctuates the drawing width of face of an aperture angle diaphragm of the above first, It is arranged in the latter part of the field diaphragm arranged in the image formation side of the image formation optical system of the above first, and the above-mentioned field diaphragm. Form the second image formation optical system which makes the image formation optical system of the above first, and telecentric system [****], and even if few, the third of a pair, and the fourth symmetry-of-revolution electrostatic lens, Are the focal plane of the image formation optical system of the above second, and it is arranged in the first focal plane of the above, and the second focal plane [****]. the direction of a major axis of an aperture angle diaphragm of the above first, and the direction which carries out an abbreviation rectangular cross -- a major axis -- carrying out -- telescopic motion -- with an aperture angle diaphragm of the second which has the metal plate of two sheets isolated in parallel with mutual by free diaphragm width of face The second aperture angle diaphragm drive which it has [second] the second piezoelectric device and fluctuates the drawing width of face of an aperture angle diaphragm of the above second, An electron beam detection means to detect the above-mentioned secondary electron beam by which image formation was carried out with the

symmetry-of-revolution lens of the above fourth, and to output as a picture signal, The substrate check system equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of the above-mentioned substrate in response to supply of the above-mentioned picture signal from the above-mentioned detection means, and the host computer which performs processing of the above-mentioned picture signal is offered.

[0024] Moreover, an electron beam exposure means to irradiate an electron beam as a primary-electron beam at the substrate which is a sample according to this invention (claim 9), The above-mentioned primary-electron beam changes whenever [incident angle], and it carries out incidence at right angles to the front face of the above-mentioned substrate. The electron beam deflection means which passes the secondary electron beam containing the secondary electron and reflection electron which were generated from the above-mentioned substrate in response to the exposure of the above-mentioned primary-electron beam with an incorporation include angle, Two or more map projection means to which image formation of the above-mentioned secondary electron beam is carried out including this electron beam deflection means, An electron beam detection means to detect the above-mentioned secondary electron beam by which image formation was carried out with the above-mentioned map projection means of the last stage, and to output as a picture signal, It is the control approach of substrate test equipment equipped with an image display means to display the image which expresses physical and the electrical condition of the front face of the above-mentioned substrate in response to supply of the above-mentioned picture signal from this electron beam detection means. Image formation of the above-mentioned secondary electron beam is controlled and carried out so that telecentric system [**** / the above-mentioned secondary electron beam / mutual] may be made with two or more above-mentioned map projection means. While securing the exposure field to the above-mentioned sample of the above-mentioned primary-electron beam by arranging an aperture angle diaphragm of the first in the first focal plane within the above-mentioned map projection means after the second step, the control approach of substrate test equipment of reducing the chromatic aberration of magnification of the above-mentioned secondary electron beam is offered.

[0025] an aperture angle diaphragm of the above first -- each -- telescopic motion -- it is good to open independently to two directions which carry out an abbreviation rectangular cross mutually, and to control an angle by having free diaphragm width of face, and each major axis's forming mutually by two movable rectangle diaphragms which carry out an abbreviation rectangular cross, and fluctuating the drawing width

of face of the above-mentioned movable rectangle diaphragm using the rectangle diaphragm driving means which it has further, respectively

[0026] Moreover, are the focal plane of the map projection means above-mentioned [the first step of], and an aperture angle diaphragm of the second is further arranged in the second focal plane in the field between the above-mentioned electron beam deflection means and the above-mentioned substrate. It forms, respectively by movable rectangle diaphragm of the first which has free diaphragm width of face, and the second. an aperture angle diaphragm of the above-mentioned first and the second -- telescopic motion -- a movable rectangle diaphragm of the above-mentioned first and the second It is still better to arrange so that each major axis may carry out an abbreviation rectangular cross mutually, to have the driving means which fluctuates each above-mentioned first and second diaphragm width of face of a movable rectangle diaphragm, to open independently to two directions which carry out an abbreviation rectangular cross, respectively mutually, and to control an angle.

[0027]

[Embodiment of the Invention] Hereafter, it explains, referring to a drawing about some of gestalten of operation of this invention. In addition, in each following drawing, the same reference number is given to the same part as ~~drawing 8~~ thru/or ~~drawing 10~~ , and the explanation is omitted suitably.

[0028] ~~Drawing 3~~ is the block diagram showing the gestalt of operation of the 1st of the substrate check system concerning this invention. In this drawing, the parts of the stage armature-voltage control section 51 which controls the primary optical system 1 with which the substrate check system 70 is equipped, the electron gun control section 16 which controls this and two or more step quadrupole lens control section 17, the electronic detecting element 3, the electronic detection control section 57 that controls this, Wien filter 41, the Wien filter control section 53 which controls this, a stage 43, and this, the picture signal processing section 58, a host computer 59, a display 60, and memory 61 are the same as that of the substrate check system 100 shown in ~~drawing 8~~ .

[0029] The description of this operation gestalt controls the third lens 23 and the fourth lens 24 by the secondary optical-system lens control sections 55 and 56 of the secondary optical system 72, and forms both telecentric system. It is a field within this image formation optical system 75, and is in the point that the aperture angle diaphragm 27 is arranged in the focal plane 9 in the focal plane 8 in which it opened in the conventional technique and the angle diaphragm 25 was installed, and conjugation, i.e., the relation which can exchange roles mutually on the occasion of image formation.

[0030] The block diagram of the secondary optical system 72 of the substrate check system 70 shown in ~~drawing 3~~ is shown in ~~drawing 4~~ .

[0031] As shown in this drawing, the secondary optical system 72 was installed between the third lens 23 and the fourth lens 24. The optical system which is equipped with the characteristic aperture angle diaphragm 27 in this operation gestalt, and the third lens 23 and the fourth lens 24 form The host computer 59 is controlling a setup of the secondary optical-system lens control sections 55 and 56 to form the image formation optical system [****] 75 in nothing and mutual for both telecentric system with the image formation optical system 105 formed with the cathode lens 21 and the second lens 22 (refer to ~~drawing 3~~).

[0032] By such configuration, in the comparison with ~~drawing 7~~ which shows the conventional technique, the secondary electron beam 6 (secondary electron / reflection electron / back scattering electron) generated from the front face of a sample 42 so that clearly After a travelling direction is controlled by the cathode lens 21, as shown in the beam orbit 7 of ~~drawing 4~~ Open in the conventional technique and incidence is carried out to the focus F1 of the focal plane 8 in which the angle diaphragm was installed. It is controlled to go straight on, without deflecting the inside of Wien filter 41, to be collimated by the second lens 22, being expanded, namely, to go on in parallel to beam ****, and image formation is carried out on a field diaphragm 26. The secondary electron beam 6 which passed the field diaphragm 26 has a travelling direction again controlled by the third lens 23, carries out incidence to the focus F2 of the aperture angle diaphragm 27 in the above-mentioned focal plane 8 and the focal plane 9 in a location [****], and carries out image formation with the fourth lens 24 on the inferior surface of tongue of the MCP detector 31. Thus, by forming a focus F2 among these lenses, without carrying out image formation of the secondary electron beam 6 between the third lens and the fourth lens By forming the image formation optical system 105 and the image formation optical system [****] 75, opening to a focal plane 8 and the focal plane [****] 9 within this image formation optical system 75, and arranging the angle diaphragm 27 The thing which do not become the hindrance of the sample exposure to the chromatic aberration of magnification of the secondary electron beam generated with the cathode lens 21 of the primary-electron beam 5 and which it opens and is suppressed by the angle diaphragm 27 becomes possible.

[0033] Next, it explains, referring to a drawing about the gestalt of operation of the 2nd of the substrate check system concerning this invention.

[0034] ~~Drawing 5~~ is the perspective view showing a part of configuration of the substrate check system concerning this operation gestalt.

[0035] As shown in this drawing, the substrate check system 80 concerning this operation gestalt has the description in the point which was prepared in the focal plane 9 of the substrate check system shown in ~~drawing 4~~ and which opened and formed the angle diaphragm 27 by two movable rectangle diaphragms 81 and 82. Other points are the same as that of the substrate check system 70 shown in ~~drawing~~ 4 .

[0036] the drawing width of face (minor-axis length) of the direction [in / respectively / the movable rectangle diaphragms 81 and 82 are arranged on a focal plane 9, and / rectangular coordinates XY] of X, and the direction of Y -- telescopic motion -- it has free structure.

[0037] ~~Drawing 6~~ is the perspective view showing the fundamental configuration of the movable rectangle diaphragm 81. As shown in this drawing, the movable rectangle diaphragm 81 is equipped with the plates 86 and 87 of two sheets formed with the metal (Mo), for example, molybdenum, and forms the diaphragm which controls the through put of the secondary electron beam 6 by the edges 86e and 87e which these metal plates 86 and 87 counter. Moreover, the movable rectangle diaphragm 81 is further equipped with the movable rectangle diaphragm control section 90 which controls the rectangle diaphragm drives 88 and 89 connected to the metal plates 86 and 87, respectively, and these rectangle diaphragm drives 88 and 89. The rectangle diaphragm drives 88 and 89 are formed using a motor, a piezoelectric device, etc., produce a strain or stress in response to impression of an electrical potential difference in this operation gestalt by the movable rectangle diaphragm control section 90, using a piezo-electric element as a piezoelectric device, and, thereby, make the metal plates 86 and 87 drive mutually to hard flow in the direction of X. The movement magnitude of the metal plates 86 and 87 by this piezoelectric device is about 100 micrometers, when a piezo-electric element is used. Thus, the rectangle diaphragm drives 88 and 89 can adjust the distance between monotonous edges of 81g, and can perform adjustment of the drawing width of face of the rectangle diaphragm 81, i.e., the direction size of X.

[0038] It has the same configuration as the movable rectangle diaphragm 81, and the metal plate is arranged so that it may intersect perpendicularly with the metal plates 86 and 87 of the movable rectangle diaphragm 81 shown in ~~drawing 6~~ , and the movable rectangle diaphragm 82 is also formed so that the direction size of Y can be adjusted.

[0039] The substrate check system 80 concerning this operation gestalt can be adjusted independently to two directions which can adjust an aperture angle diaphragm to the optimal size, and intersect perpendicularly with both flat surfaces perpendicular to the

beam shaft of the secondary electron beam 6, respectively, without doing the activity which opens wide and opens the vacuum ambient atmosphere in substrate test equipment, and exchanges an angle diaphragm, since it has two movable rectangle diaphragms 81 and 82 of such a configuration. The substrate check system which opens by this corresponding to the experimental contents in addition to the effectiveness which the gestalt of the 1st operation of a **** has, and can perform adjustment of an angle diaphragm is offered.

[0040] Next, it explains, referring to a drawing about the gestalt of operation of the 3rd of the substrate check system concerning this invention.

[0041] ~~Drawing 1~~ is the block diagram showing the fundamental configuration of the substrate check system 90 concerning this operation gestalt. The description of the substrate check system 90 applied to this operation gestalt in contrast with ~~drawing 3~~ so that clearly is [the focal plane / **** / mutual / 8 and] that it arranged the gestalt of the second operation on nine, and the movable rectangle diaphragms 91 and 92 of this specification, respectively so that each drawing major axis might intersect perpendicularly in the map projection system. Other points are the same as the 1st operation gestalt.

[0042] The more detailed configuration of the secondary optical system of the substrate check system 90 concerning this operation gestalt is shown in the perspective view of ~~drawing 2~~ .

[0043] As shown in this drawing, the movable rectangle diaphragm 91 is arranged in the focal plane 8 between Wien filter 41 and the cathode lens 21, it is this focal plane 8 and a focal plane [****], and the movable rectangle diaphragm 92 is arranged in the focal plane 9 between the third lens 23 and the fourth lens 24.

[0044] In the XYZ space of this drawing, the movable rectangle diaphragm 91 is arranged so that the direction of a major axis may turn into the direction of a major axis of the cross-section abbreviation rectangle of the primary-electron beam 5, and the same direction of Y.

[0045] without it opens the primary-electron beam 5 in the direction of Y and an angle is restricted by equipping a focal plane 8 with the movable rectangle diaphragm 91 which has such structure -- in addition -- and aperture angle adjustment of only the direction of X can be performed. Thereby, the exposure field of the primary-electron beam 5 is fully secured. This structure is effective especially when it is not desirable to irradiate the primary-electron beam 5 on a sample 42 beyond the need to avoid the charge up of a sample 42 and contamination.

[0046] Moreover, the movable rectangle diaphragm 92 on a focal plane 9 is installed so

that the direction of a major axis may turn into the direction of X, and it is arranged so that it may intersect perpendicularly with the major axis of the movable rectangle diaphragm 91. It becomes possible to carry out beam plastic surgery from two directions, the direction of X, and the direction of Y, to the secondary electron beam 6 by this, and the chromatic aberration of magnification can be reduced.

[0047] Namely, as for the secondary electron beam 6, adjustment of the aperture angle of the direction of X is performed by the movable rectangle diaphragm 91. Since adjustment of the aperture angle of the direction of Y is performed by the movable rectangle diaphragm 92 and the movable rectangle diaphragms 91 and 92 are on the conjugation side 8 of secondary optical system, and 9 further, respectively, The aberration reduction effectiveness of the case where a diaphragm of the configuration where the movable rectangle diaphragms 91 and 92 were piled up is arranged in the conjugation sides 8 and 9 to the secondary electron beam 6, respectively, and equivalence is acquired.

[0048] According to the substrate check system 90 concerning this operation gestalt, thus, to the focal planes [**** / mutual] 8 and 9 Two movable rectangle diaphragms 91 and 92 to which each direction of a major axis intersects perpendicularly mutually are established, respectively. Furthermore, since a movable rectangle diaphragm is arranged so that it may open to the focal plane 8 in which the focus F1 of the primary-electron beam 5 is formed and the drawing major axis of an angle diaphragm may serve as the same direction as the major axis of the shape of a cross-section abbreviation rectangle of the primary-electron beam 5 It becomes possible to reduce the aberration of a secondary electron beam, without restricting the exposure field of the primary-electron beam 5. Moreover, since two movable rectangle diaphragms can be arranged in a respectively different flat-surface location, as compared with the case where two movable rectangle diaphragms are prepared in a single drawing location flat surface at coincidence, it has the advantage that the installation tooth space of a drive can fully secure, like the 2nd operation gestalt.

[0049]

[Effect of the Invention] This invention does the following effectiveness so as explained in full detail above.

[0050] That is, the chromatic aberration of magnification of a secondary electron beam can be stopped, without restricting the exposure field on the substrate of a primary-electron beam, since according to the substrate test equipment concerning this invention it has the aperture angle diaphragm arranged in the focal plane within two or more map projection means to control a secondary electron beam, and the map

projection means after the 2nd step so that telecentric system [****] may be made mutually. Thereby, the inspection zone of a substrate can be expanded, without dropping the definition ability of a map projection means.

[0051] Moreover, it can adjust to the optimal diaphragm angle, without opening wide and opening the vacuum ambient atmosphere in equipment, and exchanging an angle diaphragm, since it opens to a 2-way perpendicular to a beam shaft and an angle can be adjusted respectively independently, when the direction of a major axis equips the focal plane after the 2nd above-mentioned step with the movable rectangle diaphragm of the first and the second which carries out an abbreviation rectangular cross mutually. Thereby, since the down times of equipment are sharply reducible, a utilization ratio can be raised.

[0052] Moreover, since tooth spaces, such as a drive of a movable rectangle diaphragm, can be secured in addition to the effectiveness mentioned above when the focal plane of the telecentric system between the above-mentioned electron beam outgoing radiation means and a substrate is equipped with an aperture angle diaphragm of the second and it has the above-mentioned movable rectangle diaphragm as an aperture angle diaphragm of the first and the second, the flexibility on an equipment design improves. Moreover, since a movable rectangle diaphragm of the above second is arranged so that the direction of a major axis may turn into the direction of a major axis of a primary-electron beam, and the same direction, it can extract only in the direction of a minor axis of a primary-electron beam, adjustment of width of face can be attained, it can prevent that the primary-electron beam more than an initial complement irradiates a sample, and the charge up of a sample and contamination can be prevented.

[0053] Moreover, since according to the control approach of the substrate test equipment concerning this invention image formation of the above-mentioned secondary electron beam is controlled and carried out with the above-mentioned map projection means so that telecentric system [****] may be made mutually, it becomes possible to open to a focal plane within the map projection means after the second step, and to arrange an angle diaphragm, and substrate test equipment can be controlled to do the above-mentioned effectiveness so.

[0054] Moreover, according to the substrate check system concerning this invention, a substrate can be inspected at the outstanding resolution and high effectiveness, preventing the charge up of a sample, and contamination, since above-mentioned substrate test equipment can be operated by the above-mentioned control approach.

[Translation done.]

* NOTICES *

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the gestalt of operation of the 3rd of the substrate check system concerning this invention.
[Drawing 2] It is the perspective view showing the more detailed configuration of the secondary optical system of the substrate check system shown in drawing 1 .
[Drawing 3] It is the block diagram showing the gestalt of operation of the 1st of the substrate check system concerning this invention.
[Drawing 4] It is the block diagram showing the orbit of the secondary electron beam in the substrate check system shown in drawing 3 .
[Drawing 5] It is the block diagram showing a part of the 2nd configuration of the gestalt of operation of the substrate check system concerning this invention.
[Drawing 6] It is the block diagram showing the detail of a movable rectangle diaphragm of the substrate check system shown in drawing 5 .
[Drawing 7] It is the block diagram showing the orbit of the secondary electron beam in the conventional substrate check system shown in drawing 8 .
[Drawing 8] It is the block diagram showing an example of the substrate check system by the Prior art using a Wien filter.
[Drawing 9] It is the perspective view showing the detailed configuration of the Wien filter shown in drawing 8 .
[Drawing 10] It is the explanatory view showing the function of a Wien filter which

shows (a) and (b) in ~~drawing 9~~ .

[Description of Notations]

1 Primary Optical System

2, 72, 73 Secondary optical system

3 Electronic Detecting Element

5 Primary-Electron Beam

6 Secondary Electron Beam (Travelling Direction)

7 Secondary Electron Beam Orbit

8 Nine Focal plane

11 Cathode

12 Wehnelt Cylinder

13 Anode Plate

14 Deflecting System

15 Two or More Step Quadrupole Lens

16 Electron Gun Control Section

17 Two or More Step Quadrupole Lens Control Section

21 Cathode Lens

22 Second Lens

23 Third Lens

24 Fourth Lens

25 27 Aperture angle diaphragm

26 Field Diaphragm

31 MCP Detector

32 Fluorescent Screen

33 Light Guide

34 Image Sensor

41 Wien Filter

41a, 41b Electrode

41c, 41d Magnetic pole

42 Sample

43 Stage

51 Stage Armature-voltage Control Section

52, 54-56 Secondary optical-system lens control section

53 Wien Filter Control Section

57 Electronic Detection Control Section

58 Picture Signal Processing Section

59 Host Computer

60 Display

61 Memory

70, 80, 90 Substrate check system

75,105 Image formation optical system

81, 82, 91, 92 Movable rectangle diaphragm

81g Distance between monotonous edges

86 87 Metal plate

88 89 Rectangle diaphragm drive

90 Movable Rectangle Diaphragm Control Section

[Translation done.]

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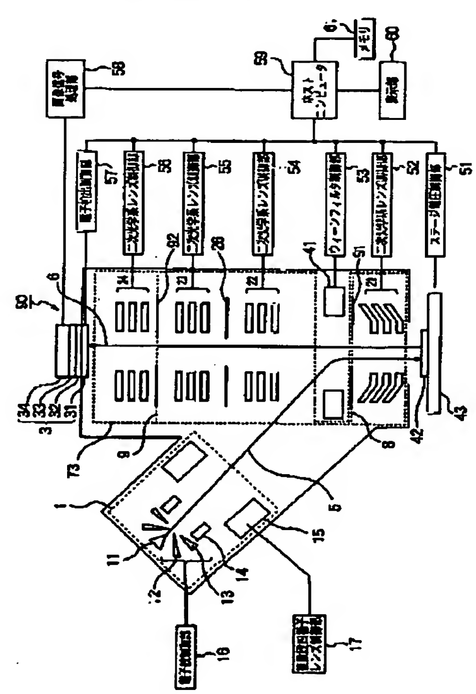
最終頁に続く

(54)【発明の名称】　基板検査装置およびこれを備えた基板検査システム並びに基板検査装置の制御方法

(57)【要約】
【課題】　一次電子ビームの照射領域を確保しつつ、二次電子ビームの倍率色収差を抑制することができる基板検査装置およびこれを備えた検査システム並びに基板検査装置の制御方法を提供する。
【解決手段】　略矩形の電子ビームを用いた基板の検査装置９０において、第三レンズ２３および第四レンズ２４を二次光学系レンズ制御部５５，５６により制御してカソードレンズ２１および第二レンズ２２で形成する結像光学系１０５と共役なテレセントリック系である結像光学系７５を形成し、相互に共役な焦点面８，９に開き角絞りを配設する。開き角絞りとして、圧電素子を用いた駆動機構に各々接続され、長軸方向で平行に配設された２枚の矩形平板を各々有し、この矩形平板の対向する辺のエッジで形成する絞り幅が調整可能な可動矩形絞り９１，９２を用いる。可動矩形絞り９１は、その長軸が一次電子ビーム５の断面形状の長軸と同一の方向となり、可動矩形絞り９２の長軸と直交するように配設する。



【特許請求の範囲】

【請求項１】試料である基板に電子ビームを一次電子ビームとして照射する一次電子ビーム照射手段と、
前記一次電子ビームは、その入射角度を変化させて前記基板の表面に垂直に入射させ、前記一次電子ビームの照射を受けて前記基板から発生した二次電子および反射電子を含む二次電子ビームは、取込み角度のまま通過させる電子ビーム偏向手段と、
前記電子ビーム偏向手段を含み、前記二次電子ビームを制御して結像させるとともに、その結像光学系が焦点の前後でビーム軸に平行に進行する領域を形成する相互に共役なテレセントリック系をなすように前記二次電子ビームを制御する複数の写像投影手段と、
最後段の前記写像投影手段により結像された前記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、
二段目以後の前記写像投影手段内の前記焦点を通り前記二次電子ビームのビーム軸に垂直な平面である焦点面に配設され、前記二次電子ビームの開き角を決定する第一の開き角絞りと、
前記電子ビーム検出手段から前記画像信号の供給を受けて、前記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段とを備えた基板検査装置。

【請求項２】前記第一の開き角絞りは、それぞれが伸縮自由な絞り幅を有し、その長軸方向が相互に略直交する第一および第二の可動矩形絞りと、これら第一および第二の可動矩形絞りの絞り幅をそれぞれ変動させる第一および第二の矩形絞り駆動手段を備えたことを特徴とする請求項１に記載の基板検査装置。

【請求項３】前記電子ビーム偏向手段と前記基板との間の領域内の前記テレセントリック系の焦点面に配設された第二の開き角絞りをさらに備え、
前記第一の開き角絞りは、前記第一の可動矩形絞りと前記第一の矩形絞り駆動手段を備え、
前記第二の開き角絞りは、前記第二の可動矩形絞りと前記第二の矩形絞り駆動手段を備え、
前記第一および第二の可動矩形絞りは、その長軸方向が相互に略直交するように配設されたことを特徴とする請求項１または２に記載の基板検査装置。

【請求項４】前記第一および第二の可動矩形絞りは、それぞれ２枚の金属平板を有し、これら２枚の金属平板が長辺において対抗して配設されることにより、前記開き角絞りを形成することを特徴とする請求項２または３に記載の基板検査装置。

【請求項５】前記矩形絞り駆動手段は、前記金属平板と接続された圧電素子を有し、この圧電素子の形状の変化に基づいて前記金属平板を駆動して前記２枚の金属平板間の距離を調整することを特徴とする請求項４に記載の基板検査装置。

【請求項６】前記一次電子ビームの照射方向に垂直な断面形状は、略矩形をなすことを特徴とする請求項１ないし５のいずれかに記載の基板検査装置。

【請求項７】ＣＰＵと、
請求項１ないし６のいずれかに記載の基板検査装置と、
前記画像信号を処理して画像データを出力する信号処理手段と、
前記画像データを格納する記憶手段とを備えた基板検査システム。

【請求項８】試料である基板に略矩形の断面形状を有する電子ビームを一次電子ビームとして照射する一次電子ビーム照射手段と、
前記一次電子ビームの照射を受けて、前記基板から発生した二次電子および反射電子を前記試料に略垂直な方向に導いて二次電子ビームとして出射させる第一の回転対称静電レンズと、
前記一次電子ビームの前記試料への入射角度を変化させて前記試料表面に垂直に前記一次電子ビームを入射させ、前記第一の回転対称静電レンズから出射された前記二次電子ビームは取り込み角度のまま通過させる電界磁界重畳型分光器と、
前記電界磁界重畳型分光器の後段に配設され、前記第一の回転対称静電レンズとともにテレセントリック系をなす第一の結像光学系を形成する第二の回転対称静電レンズと、
前記第一の結像光学系の焦点面である第一の焦点面に配設され、前記一次電子ビームの入射方向を長軸とし、伸縮自由な絞り幅で相互に平行に離隔された二枚の金属平板を有する第一の開き角絞りと、
第一の圧電素子を有し、前記第一の開き角絞りの絞り幅を変動させる第一の開き角絞り駆動機構と、
前記第一の結像光学系の結像面に配設された視野絞りと、
前記視野絞りの後段に配設され、前記第一の結像光学系と共役なテレセントリック系をなす第二の結像光学系を形成する少なくとも一対の第三および第四の回転対称静電レンズと、
前記第二の結像光学系の焦点面であって、前記第一の焦点面と共役な第二の焦点面に配設され、前記第一の開き角絞りの長軸方向と略直交する方向を長軸とし、伸縮自由な絞り幅で相互に平行に離隔された二枚の金属平板を有する第二の開き角絞りと、
第二の圧電素子を有し、前記第二の開き角絞りの絞り幅を変動させる第二の開き角絞り駆動機構と、
前記第四の回転対称レンズにより結像された前記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、
前記検出手段から前記画像信号の供給を受けて、前記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段と、
前記画像信号の処理を行うホストコンピュータとを備え

た基板検査システム。

【請求項９】試料である基板に電子ビームを一次電子ビームとして照射する電子ビーム照射手段と、前記一次電子ビームはその入射角度を変化させて前記基板の表面に垂直に入射させ、前記一次電子ビームの照射を受けて前記基板から発生した二次電子および反射電子を含む二次電子ビームは取込み角度のまま通過させる電子ビーム偏向手段と、前記電子ビーム偏向手段を含み、前記二次電子ビームを結像させる複数の写像投影手段と、最後段の前記写像投影手段により結像された前記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、前記電子ビーム検出手段から前記画像信号の供給を受けて、前記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段とを備えた基板検査装置の制御方法であって、

前記複数の写像投影手段により前記二次電子ビームが相互に共役なテレセントリック系をなすように前記二次電子ビームを制御して結像させ、

二段目以後の前記写像投影手段内の第一の焦点面に第一の開き角絞りを配設することにより、前記一次電子ビームの前記基板への照射領域を確保するとともに、前記二次電子ビームの倍率色収差を低減する、基板検査装置の制御方法。

【請求項１０】前記第一の開き角絞りは、それぞれが伸縮自由な絞り幅を有し、それぞれの長軸が相互に略直交する２つの可動矩形絞りで形成し、さらに備える矩形絞り駆動手段を用いて、前記可動矩形絞りの絞り幅をそれぞれ変動させることにより、相互に略直交する２つの方向に対して独立して開き角を制御する請求項９に記載の基板検査装置の制御方法。

【請求項１１】一段目の前記写像投影手段の焦点面であって、前記電子ビーム偏向手段と前記基板との間の領域内の第二の焦点面に第二の開き角絞りをさらに配設し、

前記第一および第二の開き角絞りは、伸縮自由な絞り幅を有する第一および第二の可動矩形絞りでそれぞれ形成し、

前記第一および第二の可動矩形絞りは、それぞれの長軸が相互に略直交するように配設し、

前記第一および第二の可動矩形絞りの各絞り幅を変動させる駆動手段を備えて、相互に略直交する二つの方向に対してそれぞれ独立して開き角を制御する請求項９に記載の基板検査装置の制御方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、電子ビームを用いた基板検査装置およびこれを用いた基板検査システム並びに基板検査方法に関し、特に、一次電子ビームの試料への照射領域を確保しつつ、倍率色収差を低減する基板検査装置およびこれを用いた基板検査システム並びに基板検査装置の制御方法に関するものである。

【０００２】

【従来の技術】半導体装置の高集積化に伴い、半導体ウェーハやフォトマスク等の基板表面上の欠陥、異物の検出に要求される感度がますます高くなり、近年は、光学式によるパターン欠陥検査の限界から光学式に替わって電子ビームを用いた半導体パターン欠陥検査装置が開発されている。この検査装置は、電子ビームを電子照射手段にて形成して一次電子ビームとして試料である基板に照射し、その試料表面の形状、材質および電位の変化に応じて発生した二次電子、反射電子および後方散乱電子を写像投影手段にて導いて集束させ、二次電子ビームとして電子検出部に拡大投影し、試料表面画像を得る装置であり、特に、特開平７－２４９３９３号公報には、線、矩形または長楕円の断面形状の電子ビームを一次電子ビームとして試料に照射することにより、走査速度を向上させる手法が提案されている。また、この手法に加えて一次電子ビームを電子ビーム偏向手段であるウィーンフィルタ（Wien filter）にて偏向させ、試料表面に対して垂直に入射させ、なおかつ二次電子ビームを同一のウィーンフィルタ内を直進させて写像投影手段に導く方法が特願平９－３００２７５号出願にて提案されている。特願平９－３００２７５号出願に示された検査装置を備えた基板検査システムの概略を図８に示す。

【０００３】同図に示す基板検査システム１００は、一次光学系１、これを制御する電子銃制御部１６および複数段四極子レンズ制御部１７、二次光学系２、これを制御する二次光学系レンズ制御部５２，５４～５６、電子検出部３、これを制御する電子検出制御部５７、ウィーンフィルタ４１、これを制御するウィーンフィルタ制御部５３、ステージ４３およびこれを制御するステージ電圧制御部５１、画像信号処理部５８、ホストコンピュータ５９、表示部６０およびメモリ６１とを備えている。

【０００４】一次光学系１は、電子銃と複数段の四極子レンズ系を備えてる。電子銃は長軸１００～７００μｍ、短軸１５μｍの矩形の電子放出面を有するランタンヘキサボライド（LaB_6という）陰極１１、矩形開口を有するウエーネルト電極（Wehnelt cylinder）１２、電子ビームを引出して一次電子ビーム５として照射する陽極１３、ビーム軸調整用の偏向器１４とを備えている。電子銃制御部１６は、一次電子ビーム５の加速電圧、出射電流などを制御する。また、四極子レンズ系は、複数段四極子レンズ制御部１７の制御に基づいて一次電子ビーム５を集束する複数段四極子レンズ１５を備えている。

【０００５】陰極１１より放出した一次電子ビーム５は、複数段の四極子レンズ１５とその制御部１７によって略矩形の断面形状を有するように収束され、ウィーンフィルタ４１に対して斜めから入射する。ここで、陰極１１は、矩形の電子放出面を有しているので、電子ビームの断面形状は略矩形となり、試料への照射領域が拡大

し、検査効率を高めることができる。なお、矩形の他に、例えば、線状、長楕円等のアスペクト比が１を超える細長形状の断面を有する電子ビームを用いても、検査効率を高めることができる。しかし、細長形状に限らず様々な断面形状の電子ビームを用いても良い。

【０００６】一次電子ビーム５はウィーンフィルタ４１によって試料４２の表面に対して垂直な方向へ偏向されてウィーンフィルタ４１を出射する。その後、一次電子ビーム５は、回転対称静電レンズであるカソードレンズ２１によって縮小され、試料４２上で長軸数百μｍ、短軸２５μｍ程度の略矩形ビームとして照射される。

【０００７】ウィーンフィルタ４１の基本的な構成を図９に示す。同図に示すように、ウィーンフィルタ４１は、それぞれ相互に対向して配置され、ウィーンフィルタ制御部５３（図８参照）によって制御される直方体の２つの電極４１ａ，４１ｂと２つの磁極４１ｃ，４１ｄとを備えている。同図に示すＸＹＺの三次元空間において、Ｚ軸を写像投影系の光軸とすると、ウィーンフィルタ４１は、Ｚ軸に垂直なＸＹ平面内で電界Ｅと磁界Ｂとを直交させた構造になっており、入射した電荷粒子に対して、ウィーン条件ｑＥ＝ｖＢ（ｑは粒子電荷、ｖは直進電荷粒子の速度）を満たす電荷粒子のみを直進させる働きをする。

【０００８】図１０（ａ），（ｂ）は、ウィーンフィルタ４１を通過する電子ビーム軌道の説明図であり、いずれも、ＸＺ平面（Ｙ＝０）で切断した図９の断面図である。図１０（ａ）に示すように、この基板検査システム１００では、ウィーンフィルタ４１に入射した一次電子ビーム５に対しては、磁界による力F_Bと電界による力F_Eが同一方向に作用して、一次電子ビーム５は試料４２の表面に対して垂直に入射するように偏向される。この一方、同図（ｂ）に示すように、二次電子ビーム６に対しては、磁界による力F_Bと電界による力F_Eが逆方向に作用し、なおかつウィーン条件$F_B=F_E$が成立しているため、二次電子ビーム６は偏向されずに直進して二次光学系に入射する。

【０００９】図8に戻り、ステージ４３は、一次電子ビーム５，二次電子ビーム６の各ビーム軸に対して水平に移動自由な機構を有し、これにより、その上面に設置する試料４２を移動させてその全表面が走査できるようになっている。また、ステージ４３は、ステージ電圧制御部５１により試料４２に負電圧が印加できるようになっている。これにより、一次電子ビーム５による試料４２への入射ダメージを低減することができる。

【００１０】電子検出部３は、ＭＣＰ（Micro Channel Plate）検出器３１と、蛍光板３２と、ライトガイド３３と、ＣＣＤ等を有する撮像素子３４とを備えている。二次光学系２を経てＭＣＰ検出器３１に入射した二次電子ビーム６は、ＭＣＰ検出器３１により増幅されて蛍光板３２に照射され、そこで発生した蛍光像は、ライトガイド３３を介して撮像素子３４にて画像信号として検出される。

【００１１】この画像信号は、画像処理部５８に供給されて各種の信号処理がなされ、画像データとしてホストコンピュータ５９に供給される。ホストコンピュータ５９は、この画像データを表示部６０にて画像表示するとともに、メモリ６１を用いた画像データの保存等を行う。

【００１２】二次光学系２は、回転対称静電レンズであるカソードレンズ２１、第二レンズ２２、第三レンズ２３、第四レンズ２４と、第二レンズ２２と第三レンズ２３との間に設置された視野絞り２６とを備えている。カソードレンズ２１、第二レンズ２２、第三レンズ２３、第四レンズ２４は、それぞれ二次光学系レンズ制御部５２，５４，５５，５６によって制御される。二次光学系２はまた、ウィーンフィルタ４１とカソードレンズ２１の間の焦点F_1を通り、ビーム軸に垂直な平面である焦点面８内に配設された開き角絞り２５を備えている。このように焦点面８の位置に開き角絞り２５を配置する理由は、二次電子ビーム６についてカソードレンズ２１のみで結像を行おうとすると、レンズ作用が強くなり収差が発生しやすいので、図７のビーム軌道７の説明図に示すように、第二レンズ２２と合わせて両テレセントリック系、即ち、入射瞳と出射瞳のいずれもが無限遠に存在する光学系を形成して１回の結像を行わせ、さらに、この結像光学系１０５の焦点面８に開き角絞り２５を設置することにより、二次電子ビーム６の倍率色収差を抑えることができるからである。

【００１３】

【発明が解決しようとする課題】しかしながら、このような構造を有する従来の基板検査システム１００では、二次電子ビーム５の倍率色収差を低減するために、開き角絞り２５の絞りを狭くすると、これにより、一次電子ビーム５の試料４２上への照射領域が制限されるという欠点があった。これは、開き角絞り２５から試料４２までの一次電子ビーム５が開き角絞り２５上の焦点F_1に入射し、カソードレンズ２１によってレンズ作用を受け、試料４２に対して垂直に照明するというケラー照明（Koehler illumination）系になっているためである。

【００１４】また、試験の内容によっては、開き角絞り２５の開口を広げたり、狭めたりしたい場合があり、これに対応して絞りの最適化を行うためには、開き角絞り２５の交換を行う必要がある。しかし、従来の技術においては、交換の度ごとに装置内の真空雰囲気を開放しなければならず、装置使用効率が非常に悪くなるという欠点があった。

【００１５】本発明は、上記事情に鑑みてなされたものであり、その目的は、一次電子ビームの照射領域を確保しつつ、二次電子ビームの倍率色収差を従来の技術と同

等に抑制することができる基板検査装置およびこれを備えた検査システム並びに基板検査装置の制御方法を提供することにある。

【0016】

【課題を解決するための手段】本発明は、以下の手段により上記課題の解決を図る。即ち、本発明（請求項1）によれば、試料である基板に電子ビームを一次電子ビームとして照射する一次電子ビーム照射手段と、上記一次電子ビームは、その入射角度を変化させて上記基板の表面に垂直に入射させ、上記一次電子ビームの照射を受けて上記基板から発生した二次電子および反射電子を含む二次電子ビームは、取込み角度のまま通過させる電子ビーム偏向手段と、この電子ビーム偏向手段を含み、上記二次電子ビームを制御して結像させるとともに、その結像光学系が焦点の前後でビーム軸に平行に進行する領域を形成する相互に共役なテレセントリック系をなすように上記二次電子ビームを制御する複数の写像投影手段と、最後段の写像投影手段により結像された上記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、二段目以後の上記写像投影手段内の焦点を通り上記二次電子ビームのビーム軸に垂直な平面である焦点面に配設され、上記二次電子ビームの開き角を決定する第一の開き角絞りと、上記電子ビーム検出手段から上記画像信号の供給を受けて、上記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段とを備えた基板検査装置が提供される。

【0017】上記第一の開き角絞りは、それぞれが伸縮自由な絞り幅を有し、その長軸方向が相互に略直交する第一および第二の可動矩形絞りと、これら第一および第二の可動矩形絞りの絞り幅をそれぞれ変動させる第一および第二の矩形絞り駆動手段を備えると良い。

【0018】本発明に係る基板検査装置は、上記電子ビーム偏向手段と上記基板との間の領域内の上記テレセントリック系の焦点面に配設された第二の開き角絞りをさらに備え、上記第一の開き角絞りは、上記第一の可動矩形絞りと上記第一の矩形絞り駆動手段を備え、上記第二の開き角絞りは、上記第二の可動矩形絞りと上記第二の矩形絞り駆動手段を備え、上記第一および第二の可動矩形絞りは、その長軸方向が相互に略直交するように配設されることが好ましい。

【0019】また、上記第一および第二の可動矩形絞りは、それぞれ2枚の金属平板を有し、これら2枚の金属平板が長辺において対抗して配設されることにより、上記開き角絞りを形成することが好ましい。

【0020】また、上記矩形絞り駆動手段は、上記金属平板と接続された圧電素子を有し、この圧電素子の形状の変化に基づいて上記金属平板を駆動して上記2枚の金属平板間の距離を調整すると良い。

【0021】また、上記一次電子ビームの照射方向に垂直な断面形状は、略矩形をなすと良い。

【0022】また、本発明（請求項7）によれば、CPUと、上述の本発明に係る基板検査装置と、上記画像信号を処理して画像データを出力する信号処理手段と、この画像データを格納する記憶手段とを備えた基板検査システムが提供される。

【0023】また、本発明（請求項8）によれば、試料である基板に略矩形の断面形状を有する電子ビームを一次電子ビームとして照射する一次電子ビーム照射手段と、上記一次電子ビームの照射を受けて、上記基板から発生した二次電子および反射電子を上記試料に略垂直な方向に導いて二次電子ビームとして出射させる第一の回転対称静電レンズと、上記一次電子ビームの上記試料への入射角度を変化させて上記試料表面に垂直に上記一次電子ビームを入射させ、上記第一の回転対称静電レンズから出射された上記二次電子ビームは同一の取り込み角度で通過させる電界磁界重畳型分光器と、この電界磁界重畳型分光器の後段に配設され、上記第一の回転対称静電レンズとともにテレセントリック系をなす第一の結像光学系を形成する第二の回転対称静電レンズと、上記第一の結像光学系の焦点面である第一の焦点面に配設され、上記一次電子ビームの入射方向を長軸とし、伸縮自由な絞り幅で相互に平行に離隔された二枚の金属平板を有する第一の開き角絞りと、第一の圧電素子を有し、上記第一の開き角絞りの絞り幅を変動させる第一の開き角絞り駆動機構と、上記第一の結像光学系の結像面に配設された視野絞りと、上記視野絞りの後段に配設され、上記第一の結像光学系と共役なテレセントリック系をなす第二の結像光学系を形成する少なくとも一対の第三および第四の回転対称静電レンズと、上記第二の結像光学系の焦点面であって、上記第一の焦点面と共役な第二の焦点面に配設され、上記第一の開き角絞りの長軸方向と略直交する方向を長軸とし、伸縮自由な絞り幅で相互に平行に離隔された二枚の金属平板を有する第二の開き角絞りと、第二の圧電素子を有し、上記第二の開き角絞りの絞り幅を変動させる第二の開き角絞り駆動機構と、上記第四の回転対称レンズにより結像された上記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、上記検出手段から上記画像信号の供給を受けて、上記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段と、上記画像信号の処理を行うホストコンピュータとを備えた基板検査システムが提供される。

【0024】また、本発明（請求項9）によれば、試料である基板に電子ビームを一次電子ビームとして照射する電子ビーム照射手段と、上記一次電子ビームはその入射角度を変化させて上記基板の表面に垂直に入射させ、上記一次電子ビームの照射を受けて上記基板から発生した二次電子および反射電子を含む二次電子ビームは取込み角度のまま通過させる電子ビーム偏向手段と、この電子ビーム偏向手段を含み、上記二次電子ビームを結像さ

せる複数の写像投影手段と、最後段の上記写像投影手段により結像された上記二次電子ビームを検出し、画像信号として出力する電子ビーム検出手段と、この電子ビーム検出手段から上記画像信号の供給を受けて、上記基板の表面の物理的・電気的状態を表す画像を表示する画像表示手段とを備えた基板検査装置の制御方法であって、上記複数の写像投影手段により上記二次電子ビームが相互に共役なテレセントリック系をなすように上記二次電子ビームを制御して結像させ、二段目以後の上記写像投影手段内の第一の焦点面に第一の開き角絞りを配設することにより、上記一次電子ビームの上記試料への照射領域を確保するとともに、上記二次電子ビームの倍率色収差を低減する、基板検査装置の制御方法が提供される。

【0025】上記第一の開き角絞りは、それぞれが伸縮自由な絞り幅を有し、それぞれの長軸が相互に略直交する2つの可動矩形絞りで形成し、さらに備える矩形絞り駆動手段を用いて、上記可動矩形絞りの絞り幅をそれぞれ変動させることにより、相互に略直交する2つの方向に対して独立して開き角を制御すると良い。

【0026】また、一段目の上記写像投影手段の焦点面であって、上記電子ビーム偏向手段と上記基板との間の領域内の第二の焦点面に第二の開き角絞りをさらに配設し、上記第一および第二の開き角絞りは、伸縮自由な絞り幅を有する第一および第二の可動矩形絞りでそれぞれ形成し、上記第一および第二の可動矩形絞りは、それぞれの長軸が相互に略直交するように配設し、上記第一および第二の可動矩形絞りの各絞り幅を変動させる駆動手段を備えて、相互に略直交する二つの方向に対してそれぞれ独立して開き角を制御するとさらによい。

【0027】

【発明の実施の形態】以下、本発明の実施の形態のいくつかについて図面を参照しながら説明する。なお、以下の各図において、図8ないし図10と同一の部分には、同一の参照番号を付してその説明を適宜省略する。

【0028】図3は、本発明に係る基板検査システムの第1の実施の形態を示すブロック図である。同図において、基板検査システム70が備える一次光学系1、これを制御する電子銃制御部16および複数段四極子レンズ制御部17、電子検出部3、これを制御する電子検出制御部57、ウィーンフィルタ41、これを制御するウィーンフィルタ制御部53、ステージ43およびこれを制御するステージ電圧制御部51、画像信号処理部58、ホストコンピュータ59、表示部60およびメモリ61の部分は、図8に示す基板検査システム100と同一である。

【0029】本実施形態の特徴は、二次光学系72の二次光学系レンズ制御部55，56により第三レンズ23および第四レンズ24を制御して両テレセントリック系を形成し、この結像光学系75内の領域であって、従来技術において開き角絞り25が設置された焦点面8と共役、即ち、結像に際して互いに役割を交換することができる関係にある焦点面9に、開き角絞り27が配設されている点にある。

【0030】図3に示す基板検査システム70の二次光学系72のブロック図を図4に示す。

【0031】同図に示すように、二次光学系72は、第三レンズ23と第四レンズ24の間に設置された、本実施形態において特徴的な開き角絞り27を備え、第三レンズ23と第四レンズ24が形成する光学系が、カソードレンズ21と第二レンズ22で形成される結像光学系105とともに両テレセントリック系をなし、相互に共役な結像光学系75を形成するように、ホストコンピュータ59が二次光学系レンズ制御部55，56の設定を制御している（図3参照）。

【0032】このような構成により、従来技術を示す図7との比較において明らかなように、試料42の表面から発生した二次電子ビーム6（二次電子／反射電子／後方散乱電子）は、カソードレンズ21によって進行方向を制御された後、図4のビーム軌道7に示すように、従来技術において開き角絞りが設置されていた焦点面8の焦点F_1に入射し、ウィーンフィルタ41内を偏向することなく直進し、拡大されながら第二レンズ22によりコリメートされ、即ち、ビーム線軸に対して平行に進行するように制御され、視野絞り26上で結像する。視野絞り26を通過した二次電子ビーム6は、再び第三レンズ23によって進行方向を制御され、上記焦点面8と共役な位置にある焦点面9にある開き角絞り27の焦点F_2に入射し、第四レンズ24によりMCP検出器31の下面で結像する。このように、二次電子ビーム6を第三レンズと第四レンズの間で結像させることなく、これらのレンズの間で焦点F_2を形成することにより、結像光学系105と共役な結像光学系75を形成し、この結像光学系75内で焦点面8と共役な焦点面9に開き角絞り27を配設することにより、カソードレンズ21で発生する二次電子ビームの倍率色収差を、一次電子ビーム5の試料照射の妨げにならない開き角絞り27で抑えることが可能となる。

【0033】次に、本発明に係る基板検査システムの第2の実施の形態について図面を参照しながら説明する。

【0034】図5は、本実施形態に係る基板検査システムの構成の一部を示す斜視図である。

【0035】同図に示すように、本実施形態に係る基板検査システム80は、図4に示す基板検査システムの焦点面9に設けられた開き角絞り27を2つの可動矩形絞り81，82で形成した点に特徴がある。その他の点は、図4に示す基板検査システム70と同一である。

【0036】可動矩形絞り81，82は、焦点面9上に配設され、それぞれ直交座標XYにおけるX方向、Y方向の絞り幅（短軸長）が伸縮自由な構造となっている。

【0037】図6は、可動矩形絞り81の基本的な構成

を示す斜視図である。同図に示すように、可動矩形絞り８１は、金属、例えばモリブデン（Ｍｏ）で形成された２枚の平板８６，８７を備え、これらの金属平板８６，８７の対向するエッジ８６ｅ，８７ｅにより二次電子ビーム６の通過量を制御する絞りを形成している。また、可動矩形絞り８１は、金属平板８６，８７にそれぞれ接続された矩形絞り駆動機構８８，８９と、これらの矩形絞り駆動機構８８，８９を制御する可動矩形絞り制御部９０をさらに備えている。矩形絞り駆動機構８８，８９は、モーターや圧電素子等を用いて形成され、本実施形態においては、圧電素子としてピエゾ素子を用い、可動矩形絞り制御部９０により電圧の印加を受けてひずみまたは応力を生じ、これにより金属平板８６，８７をＸ方向で相互に逆方向に駆動させる。この圧電素子による金属平板８６，８７の移動量は、例えばピエゾ素子を用いた場合、約１００μｍである。このようにして、矩形絞り駆動機構８８，８９は、平板エッジ間距離８１ｇを調整し、矩形絞り８１の絞り幅、即ち、Ｘ方向サイズの調整をおこなうことができる。

【００３８】可動矩形絞り８２も、可動矩形絞り８１と同様の構成を備え、その金属平板は、図６に示す可動矩形絞り８１の金属平板８６，８７と直交するように配設されて、Ｙ方向サイズを調整できるように形成されている。

【００３９】本実施形態に係る基板検査システム８０は、このような構成の２つの可動矩形絞り８１，８２を備えているので、基板検査装置内の真空雰囲気を開放して開き角絞りを交換する作業をすることなく、開き角絞りを最適なサイズに調整することができ、かつ、二次電子ビーム６のビーム軸に垂直な平面の相互に直交する二方向に対して、それぞれ独立して調整することができる。これにより、上述の第１の実施の形態が有する効果に加え、試験の内容に対応して開き角絞りの調整ができる基板検査システムが提供される。

【００４０】次に、本発明に係る基板検査システムの第３の実施の形態について図面を参照しながら説明する。

【００４１】図1は、本実施形態に係る基板検査システム９０の基本的な構成を示すブロック図である。図３との対比において明らかなように、本実施形態に係る基板検査システム９０の特徴は、その写像投影系において、相互に共役な焦点面８，９上に第二の実施の形態と同仕様の可動矩形絞り９１，９２をそれぞれの絞り長軸が直交するようにそれぞれ配設した点にある。その他の点は、第１の実施形態と同様である。

【００４２】本実施形態に係る基板検査システム９０の二次光学系のより詳細な構成を図２の斜視図に示す。

【００４３】同図に示すように、ウィーンフィルタ４１とカソードレンズ２１との間の焦点面８に可動矩形絞り９１が配設され、この焦点面８と共役な焦点面であって、第三レンズ２３と第四レンズ２４との間の焦点面９に可動矩形絞り９２が配設されている。

【００４４】同図のＸＹＺ空間において、可動矩形絞り９１は、その長軸方向が一次電子ビーム５の断面略矩形の長軸方向と同一のＹ方向となるように配設されている。

【００４５】このような構造を有する可動矩形絞り９１を焦点面８に備えることにより、一次電子ビーム５は、Ｙ方向には開き角を制限されることなく、なおかつＸ方向のみの開き角調整を行うことができる。これにより、一次電子ビーム５の照射領域が十分に確保される。この構造は、例えば、試料４２のチャージアップや汚染を回避したい場合など、一次電子ビーム５を試料４２上に必要以上に照射することが望ましくない場合に特に有効である。

【００４６】また、焦点面９上の可動矩形絞り９２は、その長軸方向がＸ方向となるように設置され、可動矩形絞り９１の長軸と直交するように配設されている。これにより、二次電子ビーム６に対してＸ方向とＹ方向の２つの方向からビーム整形することが可能になり、倍率色収差を低減することができる。

【００４７】即ち、二次電子ビーム６は可動矩形絞り９１によりＸ方向の開き角の調整が行われ、可動矩形絞り９２によりＹ方向の開き角の調整が行われ、さらに、可動矩形絞り９１，９２はそれぞれ二次光学系の共役面８，９上にあるため、二次電子ビーム６に対して、可動矩形絞り９１，９２を重ね合わせた形状の絞りを共役面８および９にそれぞれ配設した場合と等価の収差低減効果が得られる。

【００４８】このように、本実施形態に係る基板検査システム９０によれば、相互に共役な焦点面８，９に、それぞれの長軸方向が相互に直交する２つの可動矩形絞り９１，９２をそれぞれ設け、さらに、一次電子ビーム５の焦点F_1が形成される焦点面８に開き角絞りの絞り長軸が一次電子ビーム５の断面略矩形状の長軸と同一方向となるように可動矩形絞りを配設するので、一次電子ビーム５の照射領域を制限することなく、二次電子ビームの収差を低減することが可能となる。また、２つの可動矩形絞りをそれぞれ別の平面位置に配置できるため、第２の実施形態のように、単一の絞り位置平面に２つの可動矩形絞りを同時に設ける場合と比較して、駆動機構の設置スペースが十分に確保できるという利点を有する。

【００４９】

【発明の効果】以上詳述したとおり、本発明は、以下の効果を奏する。

【００５０】即ち、本発明に係る基板検査装置によれば、相互に共役なテレセントリック系をなすように二次電子ビームを制御する複数の写像投影手段と、２段目以降の写像投影手段内の焦点面に配設された開き角絞りとを備えているので、一次電子ビームの基板上の照射領域を制限することなく、二次電子ビームの倍率色収差を抑

えることができる。これにより、写像投影手段の解像性能を落とすことなく基板の検査領域を拡大することができる。

【００５１】また、上記２段目以降の焦点面に長軸方向が相互に略直交する第一および第二の可動矩形絞りを備える場合は、ビーム軸に垂直な２方向に開き角を各々独立して調整できるので、装置内の真空雰囲気を開放して開き角絞りを交換することなく、最適な絞り角に調整することができる。これにより、装置のダウンタイムを大幅に削減できるので、使用効率を高めることができる。

【００５２】また、上記電子ビーム出射手段と基板との間のテレセントリック系の焦点面に第二の開き角絞りを備え、上記可動矩形絞りを第一および第二の開き角絞りとして備える場合には、上述した効果に加え、可動矩形絞りの駆動機構等のスペースを確保できるので、装置設計上の柔軟性が向上する。また、上記第二の可動矩形絞りをその長軸方向が一次電子ビームの長軸方向と同一の方向となるように配設するので、一次電子ビームの短軸方向にのみ絞り幅の調整が可能となり、必要量以上の一次電子ビームが試料に照射することを防止し、試料のチャージアップや汚染を防止することができる。

【００５３】また、本発明にかかる基板検査装置の制御方法によれば、上記写像投影手段により、相互に共役なテレセントリック系をなすように上記二次電子ビームを制御して結像させるので、二段目以降の写像投影手段内で焦点面に開き角絞りを配設することが可能となり、上記効果を奏するように基板検査装置を制御することができる。

【００５４】また、本発明に係る基板検査システムによれば、上述の制御方法で上述の基板検査装置を作動することができるので、試料のチャージアップや汚染を防止しながら、優れた解像度と高い効率で基板の検査を行うことができる。

【図面の簡単な説明】

【図１】本発明に係る基板検査システムの第３の実施の形態を示すブロック図である。

【図２】図１に示す基板検査システムの二次光学系のより詳細な構成を示す斜視図である。

【図３】本発明に係る基板検査システムの第１の実施の形態を示すブロック図である。

【図４】図３に示す基板検査システムにおける二次電子ビームの軌道を示すブロック図である。

【図５】本発明に係る基板検査システムの第２の実施の形態の構成の一部を示すブロック図である。

【図６】図５に示す基板検査システムの可動矩形絞りの詳細を示すブロック図である。

【図７】図８に示す従来の基板検査システムにおける二次電子ビームの軌道を示すブロック図である。

【図８】ウィーンフィルタを用いた従来の技術による基板検査システムの一例を示すブロック図である。

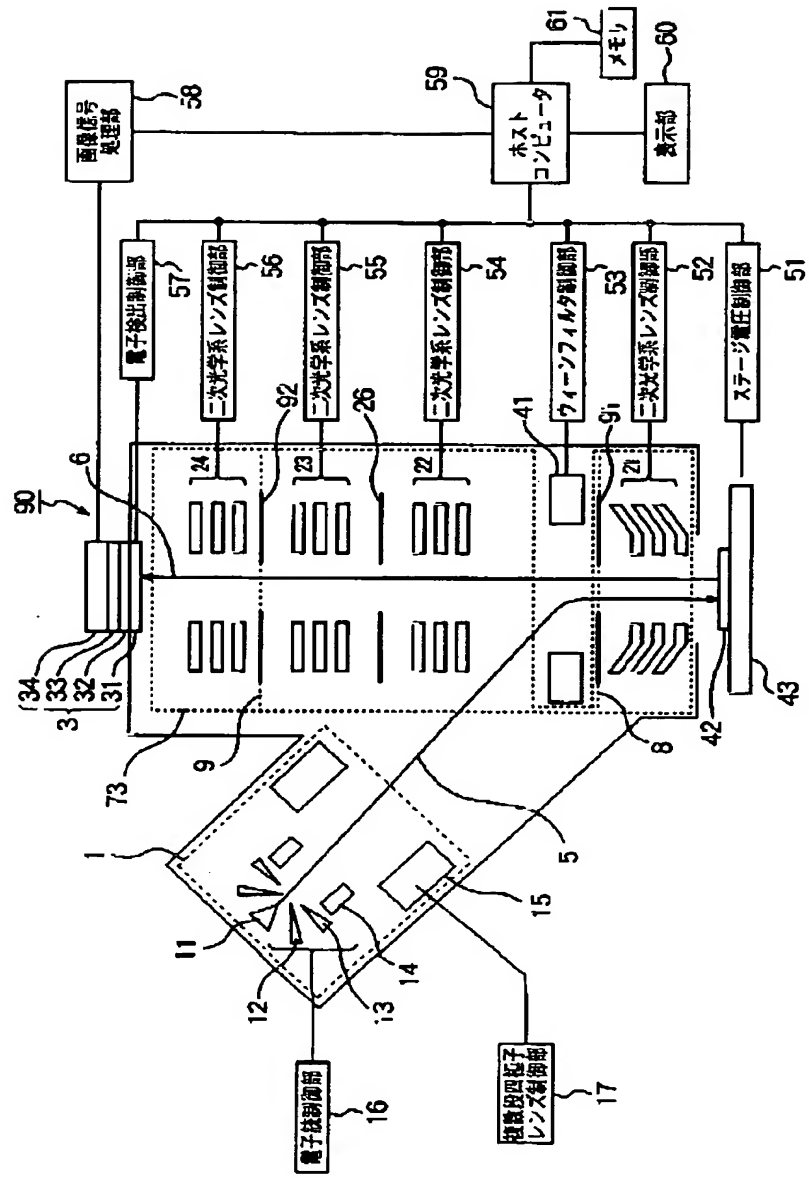
【図９】図８に示すウィーンフィルタの詳細な構成を示す斜視図である。

【図１０】（ａ），（ｂ）ともに、図９に示すウィーンフィルタの機能を示す説明図である。

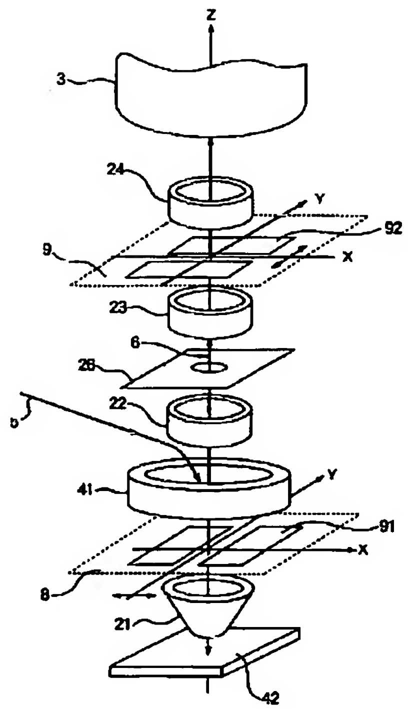
【符号の説明】

１　一次光学系
２，７２，７３　二次光学系
３　電子検出部
５　一次電子ビーム
６　二次電子ビーム（進行方向）
７　二次電子ビーム軌道
８，９　焦点面
１１　陰極
１２　ウエーネルト電極
１３　陽極
１４　偏向器
１５　複数段四極子レンズ
１６　電子銃制御部
１７　複数段四極子レンズ制御部
２１　カソードレンズ
２２　第二レンズ
２３　第三レンズ
２４　第四レンズ
２５，２７　開き角絞り
２６　視野絞り
３１　ＭＣＰ検出器
３２　蛍光板
３３　ライトガイド
３４　撮像素子
４１　ウィーンフィルタ
４１ａ，４１ｂ　電極
４１ｃ，４１ｄ　磁極
４２　試料
４３　ステージ
５１　ステージ電圧制御部
５２，５４～５６　二次光学系レンズ制御部
５３　ウィーンフィルタ制御部
５７　電子検出制御部
５８　画像信号処理部
５９　ホストコンピュータ
６０　表示部
６１　メモリ
７０，８０，９０　基板検査システム
７５，１０５　結像光学系
８１，８２，９１，９２　可動矩形絞り
８１ｇ　平板エッジ間距離
８６，８７　金属平板
８８，８９　矩形絞り駆動機構
９０　可動矩形絞り制御部

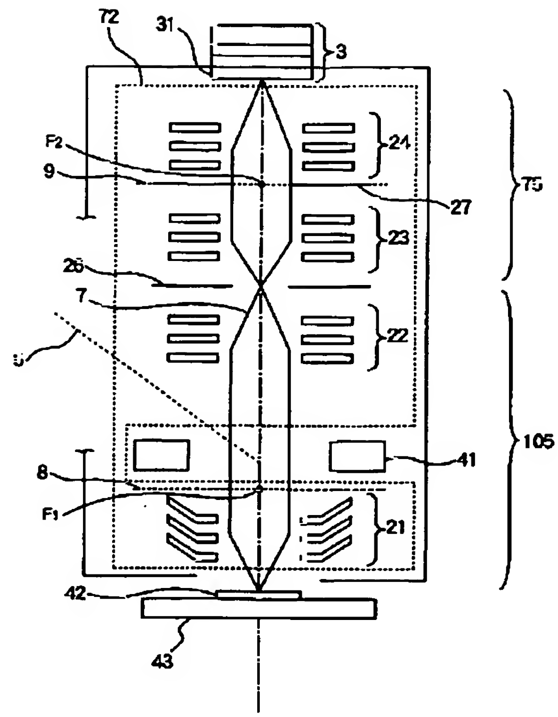
【図1】


画像信号処理部
ホストコンピュータ
メモリ
表示部
電子検出制御部
二次光学系レンズ制御部
二次光学系レンズ制御部
二次光学系レンズ制御部
ウィーンフィルタ制御部
一次光学系レンズ制御部
ステージ電圧制御部
電子銃制御部
複数段四極子レンズ制御部

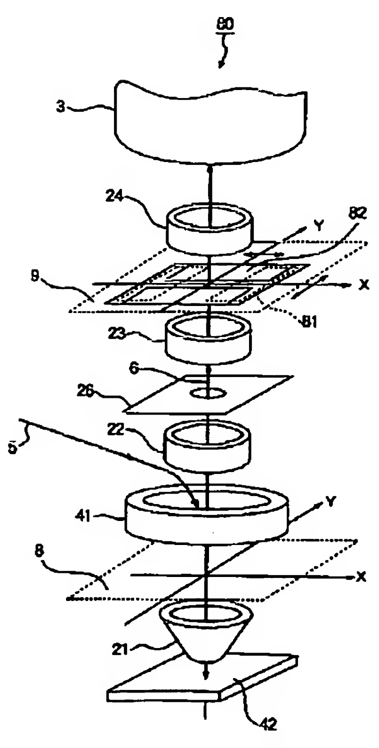
【図2】



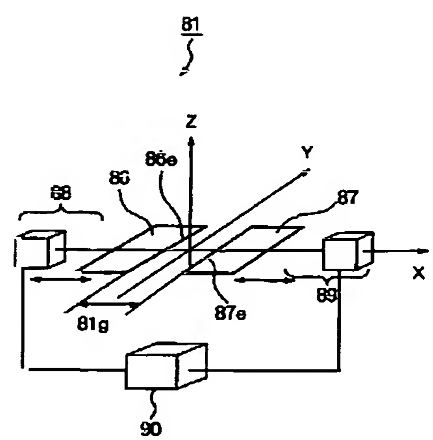
【図4】



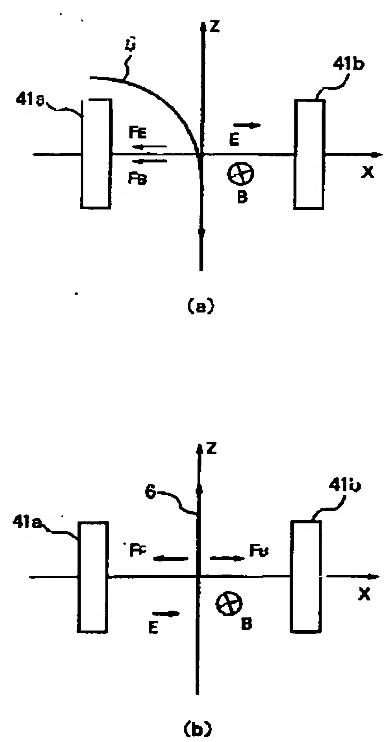
【図5】



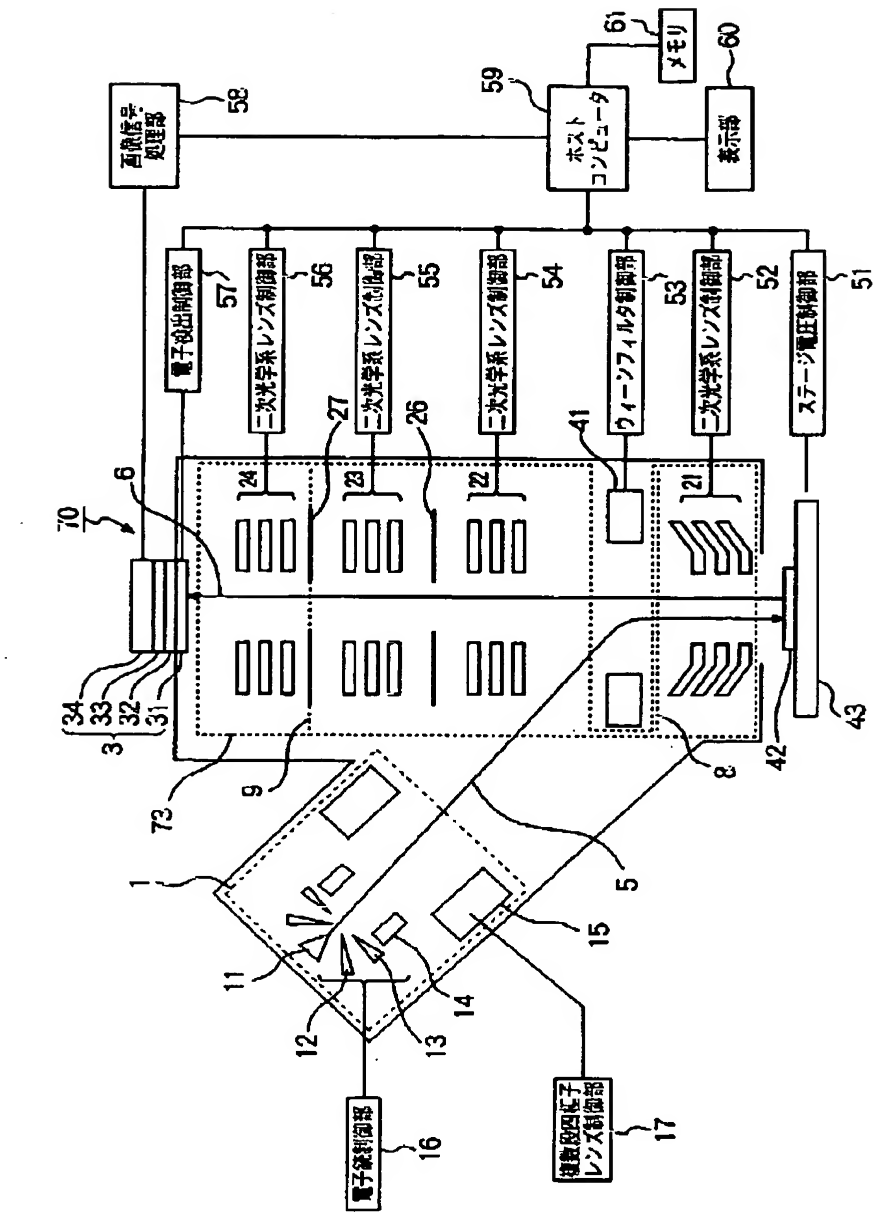
【図6】



【図10】



【図3】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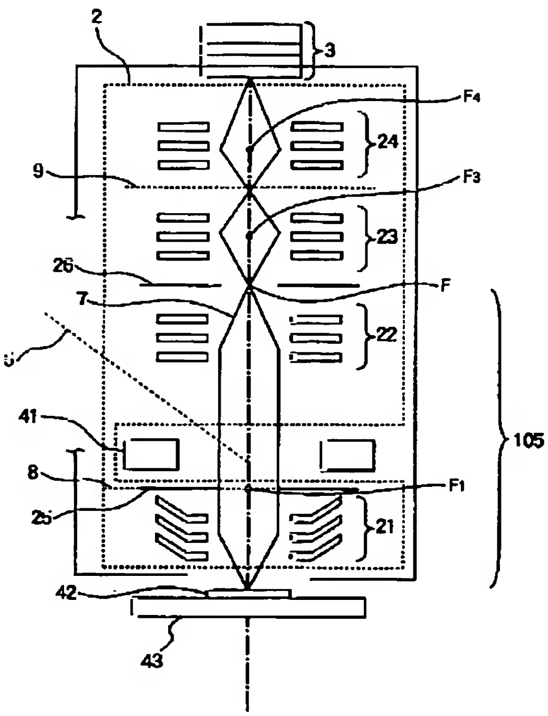
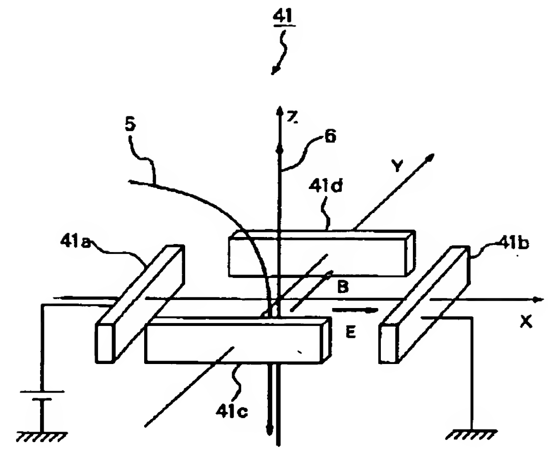
ホストコンピュータ
メモリ
表示部
電子検出制御部
二次光学系レンズ制御部
二次光学系レンズ制御部
二次光学系レンズ制御部
ウィーンフィルタ制御部
二次光学系レンズ制御部
ステージ電圧制御部
電子銃制御部
複数段四極子レンズ制御部

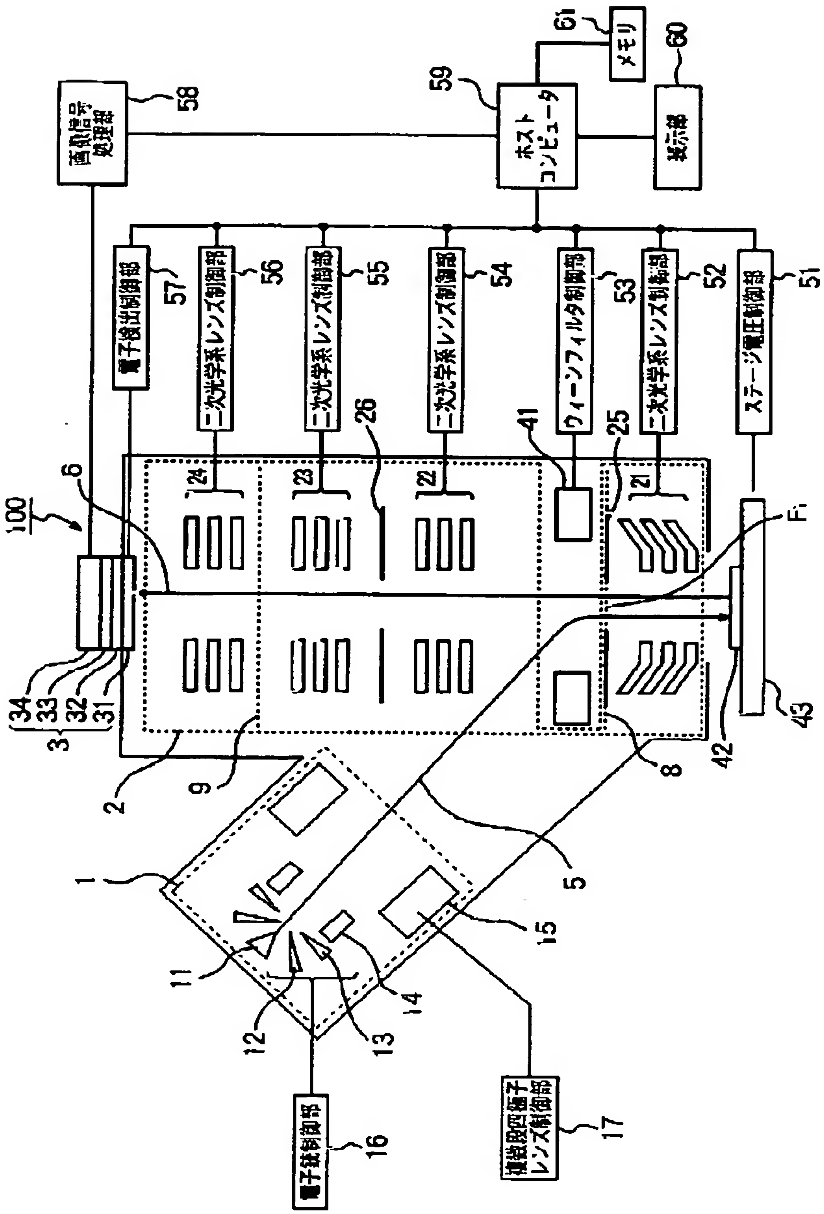
【図7】


2
3
F4
24
9
F3
23
26
F
7
22
105
41
8
F1
25
21
42
43

【図9】


41
Z
5
6
41d
Y
41a
41b
B
E
X
41c

【図8】



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